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Monthly Performance Report

RHRU, CLEMSON

MARCH 1979

U.S. Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

4238

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MONTHLY PERFORMANCE REPORT
RHRU, CLEMSON
MARCH 1979

I. SITE DESCRIPTION

The Rural Housing Research Unit (RHRU) of the United States Department of Agriculture (USDA) Science and Education Administration (SEA) solar energy site is an instrumented, combination greenhouse and residence at Clemson University, and is sponsored by the Appalachian Regional Commission and the South Carolina Agricultural Experimentation Station. The two-story house uses both active and passive solar components for space heating, space cooling, and domestic hot water heating. This site is operated by the South Carolina Agriculture Experimentation Station at Clemson, South Carolina. The active system has 381 square feet of flat-plate collectors built by the USDA. The collector array faces due south and is tilted at an angle of 60 degrees from the horizontal. Air is used as the transfer medium for delivering solar energy from the collector array to storage. The air entering the collectors may be preheated by routing it through the greenhouse, which has a projected area of 352 square feet in the plane of the collectors.

The energy is stored in 1,161 cubic feet of rock located in a storage bin beneath the house. Space heating is accomplished by circulating warmed air from the collector or the rock storage bin through the conditioned spaces. Space cooling is provided by circulating cooled air from outside or from the rock storage bin through the conditioned spaces. Auxiliary heating is furnished by 20-kilowatt electric heat strips, and auxiliary cooling is provided by a 2.5-ton air conditioner. The heat strips and the air conditioner evaporator coils are located in the air-handler unit supply plenum. Domestic hot water (DHW) is preheated by circulating city water in the 42-gallon preheat tank through an air-to-liquid heat exchanger located in the collector outlet plenum. Auxiliary hot water heating is furnished by a 4.5-kilowatt electrical element in the 42-gallon hot water tank.

The system, shown schematically in Figure 1 and pictorially in Figure 2, has three winter modes of operation, four summer modes, and a domestic hot water mode.

A. Winter Operation

Mode 1 - Storage-to-Space Heating: Warm air is transferred from the rock thermal storage by the air-handler unit to the house. Return air from the house may be recycled through the greenhouse at night under the control of manual dampers. This maintains the minimum greenhouse temperature at approximately 50°F. When the air temperature of the rock thermal storage is insufficient to satisfy the space heating demand, auxiliary energy is supplied by the electrical heat strips.

Mode 2 - Collector-to-Space Heating: During periods of adequate solar insolation, space heating is supplied to the conditioned space by drawing warm air directly from the collector outlet plenum. The return air is recycled through the solar collector for reheating and redistribution.

Mode 3 - Collector-to-Storage: During periods of adequate insolation when there is no space heating demand, warm air is routed from the collector outlet through rock thermal storage and back to the collector. To maintain a greenhouse temperature of 70°F and avoid overheating, air returning to the collector may be circulated through the greenhouse.

B. Summer Operation

Mode 1 - Purge: Cool air from outside is circulated through the rock thermal storage so that the cooler air will pick up stored energy transferred to storage from the conditioned spaces. The air bypasses the greenhouse and is vented through the solar collector to the outside.

Mode 2 - Storage-to-Space Cooling: Air that had been cooled during the previous purge mode is drawn from storage and distributed to the house. Additional cooling is supplied by the auxiliary evaporator coils located in the air-handler unit supply plenum.

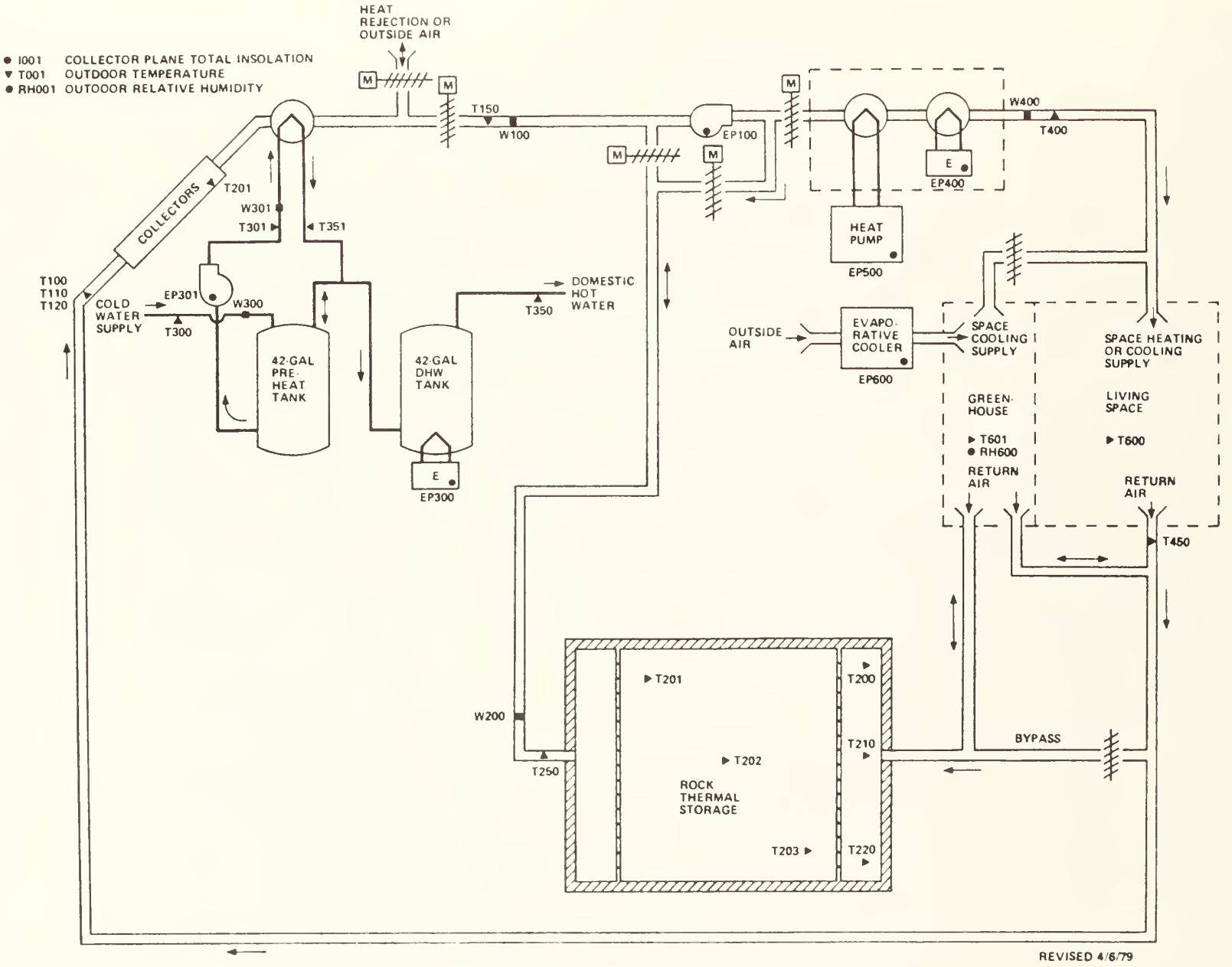

Figure 1. RHRU CLEMSON SOLAR ENERGY SYSTEM SCHEMATIC

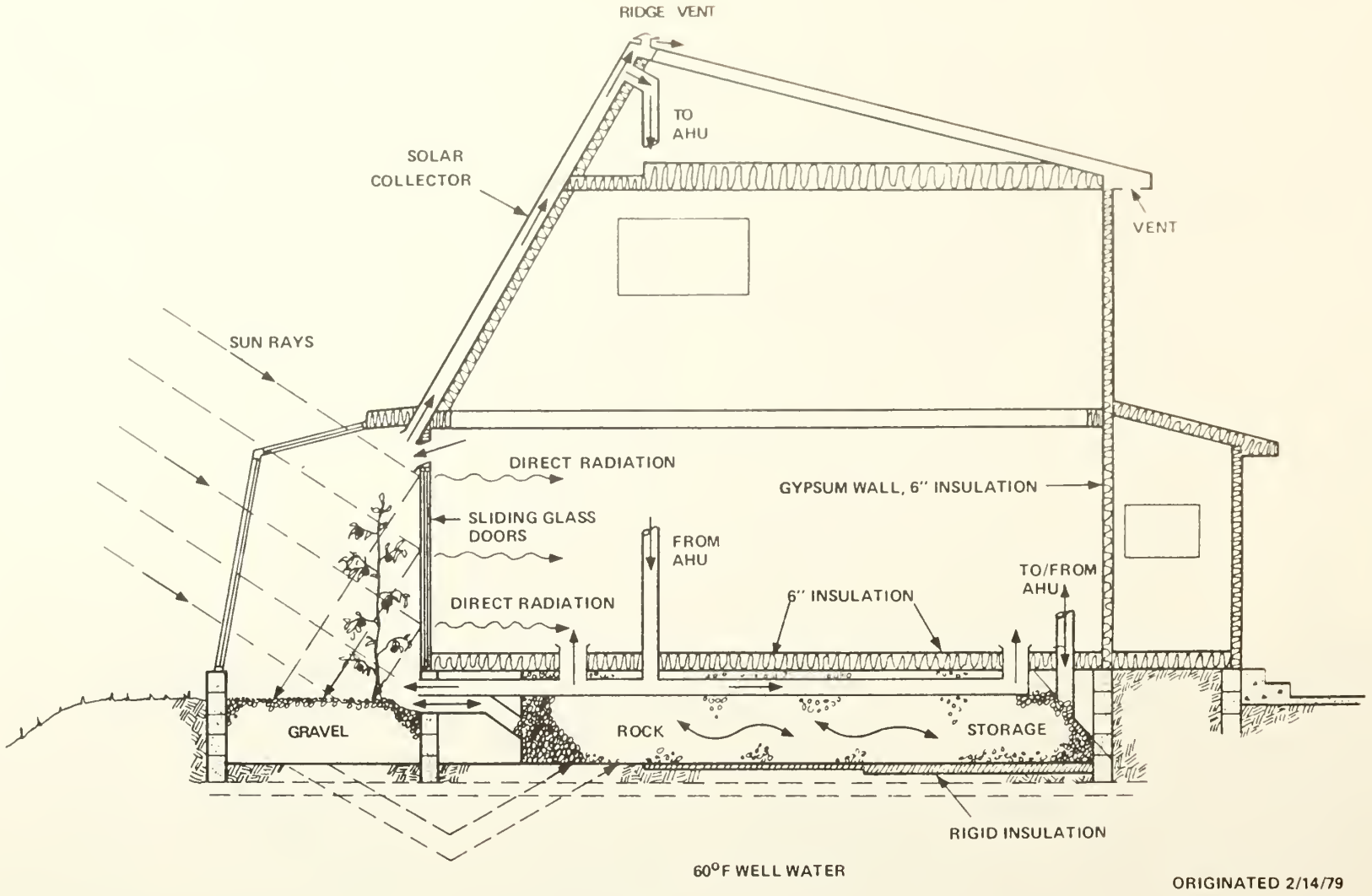

Figure 2. RHRU CLEMSON SOLAR SYSTEM PICTORAL

Mode 3 - Outside Air-to-Space Cooling: Cool air is drawn from outside and delivered to the house. The return air is recycled to the solar collector and vented to the outside.

Mode 4 - Greenhouse Venting: Solar energy absorbed by the greenhouse and collector array is vented to the outside.

C. Domestic Hot Water Operation

The DHW preheat mode is used in both winter and summer. Water from the preheat tank circulates through the air-to-water heat exchanger. Hot water flow through the heat exchanger begins when the temperature at the heat exchanger is 3°F above the preheat tank temperature, and reaches maximum flow rate when the temperature difference is 23°F. Flow stops when the temperature difference decreases below 3°F. The proportional control device ensures that the flow rate is proportional to the temperature difference. Whenever the temperature at the heat exchanger decreases below 35°F, water from the preheat tank circulates through the air-to-water heat exchanger to protect the system from freezing.

II. PERFORMANCE EVALUATION

The system performance evaluations discussed in this section are based primarily on the analysis of the data presented in the attached computer-generated monthly report. This attached report consists of daily site thermal and energy values for each subsystem, plus environmental data. The performance factors discussed in this report are based upon the definitions contained in NBSIR-76-1137, Thermal Data Requirements and Performance Evaluation Procedures for the National Solar Heating and Cooling Demonstration Program.

A. Introduction

All solar energy subsystems at the site were operational throughout the month of March. These subsystems supplied 84 percent of the total

2.3 million Btu space heating load, and 38 percent of the 1.0 million Btu domestic hot water load. Auxiliary energy contributed an additional 0.4 million Btu for space heating and 0.9 million Btu for hot water heating. The conditioned space was maintained at approximately 75 degrees. On the average, 54 gallons of hot water were used daily.

B. Weather

The average daily insolation measured in the plane of the collector array was 1,420 Btu/ft^2-day, and the long-term F-Chart predicted value was 1,563 Btu/ft^2-day. The outside daily temperature ranged from 38°F to 65°F, averaging 53°F. The long-term predicted value was 52°F, taken at the Greenville-Spartanburg airport.

C. System Thermal Performance

Collector - Of the 32.3 million Btu incident on the plane of the collectors and the projected plane of the greenhouse, 27.0 million Btu were available during the time of actual collector operation, and 7.2 million Btu were collected. The greenhouse contributed 1.7 million Btu to the 5.5 million Btu collected by the flat-plate array. The efficiency of the combined flat-plate and greenhouse operation was 22 percent. The flat-plate efficiency was 33 percent, and the greenhouse efficiency was 11 percent.

Storage - A total of 7.2 million Btu of solar energy was collected, and was utilized as follows: 5.4 million Btu were delivered to storage; 0.1 million Btu went directly to the space heating load; 0.3 million Btu were transfered to the DHW subsystem. The remaining 1.5 million Btu, although not measured, contributed to satisfying the heating load. This unmeasured amount can be due to leakage in the air ducts, and leakage through the registers in the residence and greenhouse.

For space heating the living area and greenhouse, 1.9 million Btu were removed from storage. Storage energy increased 0.3 million Btu during

the March period. The resulting storage loss was 3.2 million Btu, and the storage efficiency was 40 percent.

The average storage temperature of 83°F was much higher than the ground temperature of approximately 60°F, resulting in a net energy flow from storage to the ground.

Space Heat Load - The measured heating demand of 2.3 million Btu was satisfied by 1.89 million Btu from storage, 0.07 million Btu directly from the collector, and 0.37 million Btu auxiliary electrical energy. The energy from storage was measured between the storage inlet and outlet, thus energy dissipated in the distribution system was also attributed to the load.

The greenhouse demand of 1.8 million Btu was measured using the house supply mass air flow and return temperature, and storage inlet temperature. The main air supply duct supplied a portion of the greenhouse load via one partially opened manual register, which is not instrumented. The measured greenhouse portion can be considered a good approximation.

Hot Water Load - The measured 1.0 million Btu domestic hot water load was met by 0.3 million Btu of solar energy, and 0.9 million Btu of auxiliary energy. The solar fraction of the load, based on solar energy contributed to the preheat tank energy level supplying the load, was 38 percent. The hot water subsystem efficiency for the month, assuming no net monthly change in the energy levels of the tanks, was 86 percent. The combined solar and auxiliary energy raised the supply water temperature an average of 69°F.

D. Observations

Simulator predictions indicate passive energy being supplied to storage during the space heating season, as shown in Figure 2. For March, however, more energy was supplied to storage than needed, resulting in storage energy dissipation through the ground.

E. Energy Savings

The use of the active solar energy components in March provided a total electrical energy savings of 2.2 million Btu. This is equivalent to the additional energy required to supply the space heating and domestic hot water needs if the residence relied solely on conventional electric power.

III. ACTION STATUS

The solar energy system and the instrumentation are currently operating with no known problems.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: PHRU CLEMSON - CLEMSON,SOUTH CAROLINA SOLAR/2086-79/03
REPORT PERIOD: MARCH,1979

SITE/SYSTEM DESCRIPTION:
THE PHRU CLEMSON SOLAR ENERGY SYSTEM PROVIDES SPACE HEATING AND DOMESTIC HOT WATER PREHEATING. AIR IS USED AS THE COLLECTION MEDIUM AND TRANSFER MEDIUM FOR THE SPACE HEATING SYSTEM. COLLECTED ENERGY IS DIRECTED EITHER TO THE LOAD OR TO A ROCK BED UNIT FOR STORAGE. ELECTRIC RESISTANCE ELEMENTS PROVIDE AUXILIARY HEAT.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	32.287	MILLION BTU
	44030	BTU/SQ.FT.
COLLECTED SOLAR ENERGY	7.245	MILLION BTU
	9880	BTU/SQ.FT.
AVERAGE AMBIENT TEMPERATURE	53	DEGREES F
AVERAGE BUILDING TEMPERATURE	75	DEGREES F
FCSS SOLAR CONVERSION EFFICIENCY	0.07	
FCSS OPERATING ENERGY	0.187	MILLION BTU
TOTAL SYSTEM OPERATING ENERGY	0.363	MILLION BTU
TOTAL ENERGY CONSUMED	8.887	MILLION BTU

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	1.013	2.342	N.A.	3.355 MILLION BTU
SOLAR FRACTION	38	84	N.A.	70 PERCENT
SOLAR ENERGY USED	0.267	1.969	N.A.	2.391 MILLION BTU
OPERATING ENERGY	0.026	0.151	N.A.	0.363 MILLION BTU
AUX. THERMAL ENERGY	0.906	0.373	N.A.	1.279 MILLION BTU
AUX. ELECTRIC FUEL	0.906	0.373	N.A.	1.279 MILLION BTU
AUX. FOSSIL FUEL	N.A.	N.A.	N.A.	N.A. MILLION BTU
ELECTRICAL SAVINGS	0.396	1.969	N.A.	2.179 MILLION BTU
FOSSIL SAVINGS	N.A.	N.A.	N.A.	N.A. MILLION BTU

SYSTEM PERFORMANCE FACTOR: 0.614

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978. SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: RHRU CLEMSON - CLEMSON,SOUTH CAROLINA SOLAR/2086-79/03
REPORT PERIOD: MARCH,1979

SITE/SYSTEM DESCRIPTION:
THE RHRU CLEMSON SOLAR ENERGY SYSTEM PROVIDES SPACE HEATING AND DOMESTIC HOT WATER PREHEATING. AIR IS USED AS THE COLLECTION MEDIUM AND TRANSFER MEDIUM FOR THE SPACE HEATING SYSTEM. COLLECTED ENERGY IS DIRECTED EITHER TO THE LOAD OR TO A ROCK BED UNIT FOR STORAGE. ELECTRIC RESISTANCE ELEMENTS PROVIDE AUXILIARY HEAT.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	34.063 GIGA JOULES
	500005 KJ/SQ.M.
COLLECTED SOLAR ENERGY	7.644 GIGA JOULES
	112202 KJ/SQ.M.
AVERAGE AMBIENT TEMPERATURE	12 DEGREES C
AVERAGE BUILDING TEMPERATURE	24 DEGREES C
FOSS SOLAR CONVERSION EFFICIENCY	0.07
FOSS OPERATING ENERGY	0.197 GIGA JOULES
TOTAL SYSTEM OPERATING ENERGY	0.383 GIGA JOULES
TOTAL ENERGY CONSUMED	9.376 GIGA JOULES

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	1.068	2.471	N.A.	3.540 GIGA JOULES
SOLAR FRACTION	38	84	N.A.	70 PERCENT
SOLAR ENERGY USED	0.282	2.078	N.A.	2.523 GIGA JOULES
OPERATING ENERGY	0.027	0.159	N.A.	0.383 GIGA JOULES
AUX. THERMAL ENG	0.956	0.394	N.A.	1.350 GIGA JOULES
AUX. ELECTRIC FUEL	0.956	0.394	N.A.	1.350 GIGA JOULES
AUX. FOSSIL FUEL	N.A.	N.A.	N.A.	N.A. GIGA JOULES
ELECTRICAL SAVINGS	0.418	2.078	N.A.	2.299 GIGA JOULES
FOSSIL SAVINGS	N.A.	N.A.	N.A.	N.A. GIGA JOULES

SYSTEM PERFORMANCE FACTOR: 0.614

* DENOTES UNAVAILABLE DATA
0 DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978, SOLAR/0004-78/18

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SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SITE: RHPU CLEMSON - CLEMSON, SOUTH CAROLINA
REPORT PERIOD: MARCH, 1979

SOLAR/2086-79/03

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LOADS MILLION BTU	AUX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU	ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
1	0.479	48	0.214	N	0.004	N	0.453
2	1.167	53	0.120	O	0.007	O	0.106
3	0.088	53	0.171	T	0.000	T	2.015
4	0.083	60	0.027		0.000		0.390
5	1.393	58	0.063	A	0.008	A	0.051
6	1.357	51	0.140	P	0.008	P	0.110
7	1.315	47	0.099	P	0.009	P	0.079
8	0.931	47	0.062	L	0.006	L	0.070
9	1.607	48	0.133	I	0.010	I	0.088
10	0.572	48	0.041	C	0.005	C	0.081
11	1.687	44	0.216	A	0.008	A	0.139
12	1.672	49	0.199	B	0.010	B	0.121
13	1.410	53	0.043	L	0.009	L	0.035
14	1.003	56	0.008	E	0.006	E	0.018
15	1.673	50	0.012		0.009		0.006
16	1.233	41	0.035		0.006		0.026
17	1.545	47	0.045		0.008		0.039
18	1.489	57	0.013		0.008		0.005
19	1.305	61	0.009		0.008		0.014
20	1.250	65	0.011		0.007		0.013
21	0.767	63	0.009		0.003		0.013
22	0.158	56	0.001		0.000		0.068
23	0.114	56	0.000		0.000		0.045
24	0.562	48	0.066		0.001		0.102
25	0.504	38	0.310		0.001		0.622
26	1.576	45	0.108		0.010		0.073
27	1.040	54	0.044		0.009		0.039
28	1.406	58	0.011		0.010		0.009
29	0.818	59	0.009		0.006		0.019
30	1.014	63	0.005		0.007		0.010
31	0.868	64	0.009		0.004		0.018
SUM	32.287	-	2.236	N.A.	0.187	N.A.	-
AVG	1.042	53	0.072	N.A.	0.006	N.A.	0.074
NBS ID	Q001	N113			Q102		N111

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

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SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
COLLECTOR ARRAY PERFORMANCE

SITE: PHRU CLEMSON - CLEMSON, SOUTH CAROLINA SOLAR/2086-79/03
REPORT PERIOD: MARCH, 1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	0.479	0.381	0.105	51	0.220
2	1.167	1.071	0.304	65	0.261
3	0.088	0.000	0.000	56	0.004
4	0.083	0.000	0.003	62	0.041
5	1.393	1.326	0.319	64	0.229
6	1.357	1.294	0.335	60	0.247
7	1.315	1.229	0.337	60	0.257
8	0.931	0.761	0.198	54	0.212
9	1.607	1.518	0.404	60	0.251
10	0.572	0.362	0.110	57	0.193
11	1.687	1.522	0.325	40	0.192
12	1.672	1.568	0.420	61	0.251
13	1.410	1.308	0.366	64	0.259
14	1.003	0.870	0.230	61	0.230
15	1.673	1.495	0.380	59	0.227
16	1.233	0.913	0.250	52	0.203
17	1.545	1.326	0.340	61	0.226
18	1.489	1.244	0.349	73	0.235
19	1.395	1.210	0.326	73	0.233
20	1.250	1.074	0.291	77	0.233
21	0.767	0.565	0.140	72	0.183
22	0.158	0.000	0.001	58	0.009
23	0.114	0.000	0.002	57	0.015
24	0.662	0.126	0.028	49	0.043
25	0.504	0.077	0.016	41	0.032
26	1.576	1.473	0.387	52	0.246
27	1.049	0.923	0.291	67	0.277
28	1.406	1.322	0.374	67	0.266
29	0.818	0.624	0.203	68	0.247
30	1.014	0.834	0.248	71	0.244
31	0.868	0.548	0.152	72	0.175
SUM	32.287	26.964	7.245	-	-
AVG	1.042	0.870	0.234	61	0.224
NBSIO	0001		0100		N100

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

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SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
STORAGE PERFORMANCE

SITE: RHPU CLEMSON - CLEMSON, SOUTH CAROLINA SOLAR/2086-79/03
REPORT PERIOD: MARCH, 1979

DAY OF MONTH	ENERGY TO STORAGE MILLION BTU	ENERGY FROM STORAGE MILLION BTU	CHANGE IN STORED ENERGY MILLION BTU	STORAGE AVERAGE TEMP DEG F	STORAGE EFFICIENCY
1	0.079	0.202	-0.178	71	0.296
2	0.223	0.095	0.134	70	1.023
3	0.000	0.171	-0.212	68	1.000
4	0.000	0.024	0.009	65	1.000
5	0.230	0.043	0.157	70	0.868
6	0.246	0.119	0.095	72	0.869
7	0.263	0.089	0.083	78	0.653
8	0.152	0.055	-0.019	80	0.234
9	0.307	0.119	0.109	81	0.744
10	0.088	0.037	-0.065	84	-0.328
11	0.224	0.185	-0.038	80	0.654
12	0.317	0.182	0.065	80	0.778
13	0.284	0.031	0.100	85	0.461
14	0.175	0.000	0.013	88	0.073
15	0.282	0.000	0.091	91	0.323
16	0.191	0.028	-0.043	92	-0.080
17	0.258	0.032	0.041	92	0.284
18	0.254	0.000	0.043	94	0.170
19	0.242	0.000	0.038	96	0.157
20	0.210	0.000	0.023	98	0.111
21	0.094	0.000	-0.065	97	-0.694
22	0.000	0.000	-0.093	93	1.000
23	0.000	0.000	-0.083	89	1.000
24	0.015	0.060	-0.108	85	-3.169
25	0.006	0.302	-0.281	75	3.734
26	0.285	0.086	0.183	71	0.941
27	0.230	0.035	0.087	78	0.534
28	0.283	0.000	0.164	85	0.578
29	0.157	0.000	0.012	89	0.075
30	0.194	0.000	0.045	91	0.235
31	0.111	0.000	-0.017	91	-0.156
SUM	5.400	1.893	0.288	-	-
AVG	0.174	0.061	0.009	83	0.404
NBS ID	0200	0201	0202		N108

* DENOTES UNAVAILABLE DATA.
0 DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
HOT WATER SUBSYSTEM

SITE: RHEE CLEMSON - CLEMSON, SOUTH CAROLINA
REPORT PERIOD: MARCH, 1979

SOLAR/2086-79/03

DAY OF MON.	HOT WATER LOAD MILLION BTU	SOLAR FRACTION LOAD PER CENT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	SUP. WAT. TEMP DEG F	HOT WAT. TEMP DEG F	HOT WATER USED GAL
1	0.023	38	0.006	0.000	0.023	0.023	N	0.008	N	58	125	37
2	0.044	32	0.014	0.001	0.035	0.035	O	0.017	O	62	125	76
3	0.027	27	0.000	0.000	0.025	0.025	T	0.006	T	52	130	34
4	0.041	21	0.003	0.000	0.047	0.047		0.009		52	130	64
5	0.024	52	0.009	0.001	0.019	0.019	A	0.015	A	58	128	38
6	0.045	43	0.011	0.001	0.036	0.036	P	0.019	P	60	126	73
7	0.040	30	0.011	0.001	0.034	0.034	P	0.014	P	57	127	63
8	0.025	37	0.008	0.001	0.024	0.024	L	0.010	L	54	130	39
9	0.037	47	0.010	0.001	0.024	0.024	I	0.017	I	58	130	54
10	0.023	37	0.005	0.000	0.028	0.028	C	0.009	C	54	126	37
11	0.073	49	0.015	0.001	0.052	0.052	A	0.032	A	53	127	110
12	0.023	52	0.011	0.001	0.017	0.017	B	0.014	B	61	124	35
13	0.043	30	0.013	0.001	0.036	0.036	L	0.017	L	52	125	72
14	0.042	46	0.008	0.001	0.033	0.033	E	0.017	E	61	127	70
15	0.018	43	0.012	0.001	0.017	0.017		0.008		54	130	29
16	0.011	34	0.007	0.001	0.014	0.014		0.003		54	129	18
17	0.065	44	0.013	0.001	0.045	0.045		0.027		57	126	108
18	0.022	22	0.013	0.001	0.026	0.026		0.006		62	128	34
19	0.031	50	0.009	0.001	0.020	0.020		0.018		65	123	50
20	0.031	47	0.011	0.001	0.021	0.021		0.016		60	128	49
21	0.022	40	0.009	0.001	0.023	0.023		0.010		57	130	36
22	0.041	31	0.001	0.000	0.041	0.041		0.011		58	128	76
23	0.027	17	0.002	0.000	0.032	0.032		0.005		56	119	48
24	0.028	18	0.006	0.001	0.033	0.033		0.007		56	121	48
25	0.033	21	0.005	0.000	0.036	0.036		0.008		57	129	53
26	0.043	35	0.013	0.001	0.039	0.039		0.018		62	119	77
27	0.021	34	0.008	0.001	0.025	0.025		0.004		63	128	35
28	0.028	31	0.011	0.001	0.026	0.026		0.012		58	132	45
29	0.036	46	0.009	0.001	0.031	0.031		0.014		58	129	68
30	0.017	41	0.005	0.001	0.015	0.015		0.010		57	130	28
31	0.037	40	0.009	0.001	0.030	0.030		0.015		60	128	66
SUM	1.013	-	0.267	0.026	0.906	0.906	N.A.	0.396	N.A.	-	-	1679
AVG	0.033	38	0.009	0.001	0.029	0.029	N.A.	0.013	N.A.	58	127	54
NBS	Q302	N300	Q300	Q303	Q301	Q305	Q306	Q311	Q313	N305	N307	N308

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

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SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SPACE HEATING SUBSYSTEM

SITE: PHRJ CLEMSON - CLEMSON,SOUTH CAROLINA SOLAR/2086-79/03
REPORT PERIOD: MARCH,1979

DAY OF MON.	SPACE HEATING LOAD MILLION BTU	SOLAR FR.OF LOAD PCT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	BLDG TEMP DEG. F	AMB TEMP DEG. F
1	0.208	100	0.208	0.014	0.000	0.000	N	0.208	N	76	48
2	0.173	51	0.106	0.009	0.067	0.067	O	0.106	O	77	53
3	0.194	88	0.171	0.010	0.023	0.023	T	0.171	T	75	53
4	0.133	18	0.024	0.013	0.110	0.110		0.024		74	60
5	0.104	52	0.054	0.008	0.050	0.050	A	0.054	A	76	58
6	0.141	92	0.129	0.009	0.012	0.012	P	0.129	P	77	51
7	0.089	100	0.089	0.004	0.000	0.000	P	0.089	P	75	47
8	0.055	100	0.055	0.003	0.000	0.000	L	0.055	L	74	47
9	0.123	100	0.123	0.007	0.000	0.000	I	0.123	I	75	48
10	0.037	100	0.037	0.002	0.000	0.000	C	0.037	C	73	48
11	0.201	100	0.201	0.012	0.000	0.000	A	0.201	A	73	44
12	0.188	100	0.188	0.010	0.000	0.000	B	0.188	P	75	49
13	0.031	100	0.031	0.001	0.000	0.000	L	0.031	L	76	53
14	0.000	0	0.000	0.000	0.000	0.000	E	0.000	E	76	56
15	0.000	0	0.000	0.000	0.000	0.000		0.000		75	50
16	0.028	100	0.028	0.001	0.000	0.000		0.028		73	41
17	0.032	100	0.032	0.001	0.000	0.000		0.032		73	47
18	0.000	0	0.000	0.000	0.000	0.000		0.000		77	57
19	0.000	0	0.000	0.000	0.000	0.000		0.000		80	61
20	0.000	0	0.000	0.000	0.000	0.000		0.000		80	65
21	0.000	0	0.000	0.000	0.000	0.000		0.000		72	63
22	0.000	0	0.000	0.000	0.000	0.000		0.000		70	56
23	0.000	0	0.000	0.000	0.000	0.000		0.000		71	56
24	0.060	100	0.060	0.005	0.000	0.000		0.060		71	48
25	0.305	100	0.305	0.024	0.000	0.000		0.305		69	38
26	0.205	46	0.095	0.007	0.111	0.111		0.095		71	45
27	0.035	100	0.035	0.002	0.000	0.000		0.035		74	54
28	0.000	0	0.000	0.000	0.000	0.000		0.000		77	58
29	0.000	0	0.000	0.000	0.000	0.000		0.000		79	59
30	0.000	0	0.000	0.000	0.000	0.000		0.000		80	63
31	0.000	0	0.000	0.000	0.000	0.000		0.000		79	64
SUM	2.343	-	1.969	0.151	0.373	0.373	N.A.	1.969	N.A.	-	-
AVG	0.076	84	0.064	0.005	0.012	0.012	N.A.	0.064	N.A.	75	53
NBS	Q402	N400	Q400	Q403	Q401		Q410	Q415	Q417	N406	N113

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENVIRONMENTAL SUMMARY

SITE: PHPU CLEMSON - CLEMSON, SOUTH CAROLINA SOLAR/2086-79/03
REPORT PERIOD: MARCH, 1979

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	653	N	48	51	87	N	N
2	1591	O	53	65	81	O	O
3	120	T	53	56	89	T	T
4	114		60	62	99		
5	1899	A	58	64	68	A	A
6	1850	P	51	60	57	P	P
7	1793	P	47	60	70	P	P
8	1270	L	47	54	82	L	L
9	2192	I	48	60	71	I	I
10	780	C	48	57	88	C	C
11	2301	A	44	49	57	A	A
12	2280	B	40	61	49	B	B
13	1923	L	53	64	65	L	L
14	1768	E	56	61	58	E	E
15	2281		50	59	37		
16	1681		41	52	54		
17	2107		47	61	70		
18	2030		57	73	67		
19	1903		61	73	64		
20	1704		65	77	70		
21	1046		63	72	83		
22	216		56	58	88		
23	156		56	57	99		
24	903		48	49	81		
25	687		38	41	74		
26	2149		45	52	61		
27	1431		54	67	62		
28	1918		58	67	66		
29	1116		59	68	79		
30	1383		63	71	73		
31	1184		64	72	79		
SUM	44030	N.A.	-	-	-	-	-
AVG	1420	N.A.	53	61	72	N.A.	N.A.
NBS ID	0001		N113			N115	N114

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@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

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SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
GREENHOUSE PERFORMANCE

SITE: RHRU CLEMSON - CLEMSON,SOUTH CAROLINA SOLAR/2086-79/03
REPORT PERIOD: MARCH,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	ENERGY FROM GREENHOUSE MILLION BTU	ENERGY TO GREENHOUSE MILLION BTU	GREENHOUSE TEMP DEG F	GREENHOUSE RELATIVE HUMIDITY PERCENT	GREENHOUSE &RESIDENCE ELECTRIC LOAD MILLIONBTU
1	0.230	0.036	0.183	65	70.5	0.083
2	0.560	0.079	0.123	66	68.2	0.166
3	0.042	0.000	0.213	62	76.8	0.115
4	0.040	0.000	0.181	64	83.6	0.232
5	0.668	0.073	0.083	70	66.2	0.125
6	0.651	0.083	0.105	69	62.1	0.105
7	0.631	0.088	0.069	64	67.8	0.083
8	0.447	0.053	0.038	64	71.1	0.069
9	0.772	0.098	0.091	67	65.5	0.094
10	0.275	0.037	0.026	61	74.9	0.072
11	0.810	0.069	0.136	66	57.7	0.124
12	0.803	0.101	0.134	68	58.5	0.080
13	0.677	0.095	0.022	67	65.0	0.093
14	0.482	0.058	0.000	68	64.8	0.084
15	0.803	0.077	0.000	67	55.0	0.063
16	0.592	0.062	0.018	64	59.5	0.057
17	0.741	0.076	0.022	67	59.9	0.113
18	0.715	0.066	0.000	70	62.2	0.082
19	0.670	0.061	0.000	72	64.3	0.068
20	0.600	0.049	0.000	73	68.1	0.070
21	0.368	0.020	0.000	72	74.1	0.060
22	0.076	0.000	0.000	64	81.7	0.075
23	0.055	0.000	0.000	61	87.3	0.067
24	0.318	0.004	0.039	62	68.7	0.074
25	0.242	0.002	0.223	60	60.4	0.112
26	0.756	0.104	0.096	67	57.9	0.211
27	0.504	0.091	0.027	67	64.9	0.072
28	0.675	0.097	0.000	70	68.1	0.077
29	0.393	0.064	0.000	70	70.4	0.071
30	0.487	0.069	0.000	74	69.1	0.056
31	0.417	0.038	0.000	74	69.2	0.073
SUM	15.499	1.748	1.830	-	-	2.925
AVG	0.500	0.056	0.059	67	67.538	0.094

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COCLING DEMONSTRATION PROGRAM

MONTHLY REPCRT
FLAT PLATE COLLECTOR ARRAY PERFORMANCE

SITE: RHRU CLEMSCN - CLEMSCN,SOUTH CAROLINA
SOLAR/2086-79/03
REPORT PERIOD: MARCH,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F
1	0.249	0.198	0.069	51
2	0.607	0.557	0.225	65
3	0.046	0.000	0.000	56
4	0.043	0.000	0.003	62
5	0.724	0.690	0.245	64
6	0.705	0.673	0.253	60
7	0.684	0.639	0.249	60
8	0.484	0.396	0.144	54
9	0.836	0.789	0.305	60
10	0.297	0.188	0.073	57
11	0.877	0.791	0.256	49
12	0.869	0.815	0.319	61
13	0.733	0.680	0.271	64
14	0.522	0.452	0.172	61
15	0.870	0.777	0.304	59
16	0.641	0.475	0.189	52
17	0.803	0.690	0.274	61
18	0.774	0.647	0.284	73
19	0.726	0.629	0.265	73
20	0.650	0.558	0.243	77
21	0.399	0.294	0.120	72
22	0.082	0.000	0.001	58
23	0.060	0.000	0.002	57
24	0.344	0.066	0.025	49
25	0.262	0.040	0.014	41
26	0.819	0.766	0.284	52
27	0.546	0.480	0.200	67
28	0.731	0.687	0.278	67
29	0.426	0.325	0.138	68
30	0.527	0.434	0.179	71
31	0.451	0.285	0.114	72
SUM	16.789	14.021	5.497	-
AVG	0.542	0.452	0.177	61
NBSID	Q001		Q100	

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
EXTREMA

SITE: RHRU CLEMSON - CLEMSON,SOUTH CAROLINA SOLAR/2086-79/03
REPORT PERIOD: MARCH,1979

DAY OF MONTH	GREENHOUSE MAXIMUM TEMP DEG F	GREENHOUSE MINIMUM TEMP DEG F	GREENHOUSE MAXIMUM RELATIVE HUMIDITY PERCENT	GREENHOUSE MINIMUM RELATIVE HUMIDITY PERCENT	COLLECTOR OUTLET MAXIMUM TEMP DEG F
1	89	55	86.6	43.1	107
2	91	54	79.6	37.1	127
3	69	56	87.4	69.0	81
4	68	61	89.1	79.0	76
5	93	57	88.4	32.6	128
6	94	51	80.1	36.8	130
7	90	46	91.4	36.7	131
8	87	50	87.8	44.8	121
9	93	47	88.6	35.9	126
10	79	48	91.1	52.3	96
11	92	49	84.1	33.0	118
12	95	54	78.0	35.0	130
13	93	46	89.0	38.9	125
14	96	55	84.2	39.0	123
15	95	48	73.6	35.9	131
16	98	42	78.3	36.5	123
17	93	41	83.0	38.9	123
18	92	49	80.8	44.4	132
19	91	54	78.1	49.8	130
20	91	60	81.9	52.0	131
21	90	61	87.3	50.9	128
22	79	60	86.8	67.3	83
23	76	57	90.8	73.4	78
24	82	51	89.2	45.3	107
25	81	51	77.8	41.3	88
26	96	49	75.1	39.5	124
27	91	48	84.5	44.4	117
28	92	52	84.4	47.6	126
29	91	54	84.0	49.7	114
30	91	58	83.5	50.5	122
31	91	60	84.1	50.0	113
SUM	-	-	-	-	-
AVG	89	52	84.2	46.1	116

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